

Status Update on Development and Deployment of Codes and Standards for Energy Storage System Safety

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Support from DOE Office of Electricity Delivery & Energy Reliability
Energy Storage Program

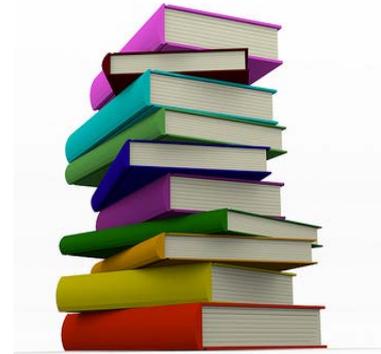
EESAT
Portland, OR
September 22, 2015



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Agenda

- ▶ Project Overview
- ▶ Purpose and expected outcome
- ▶ Overview of DOE OE Energy Storage System (ESS) Safety Plan
- ▶ Codes, Standards, and Regulations (CSR) component of the ESS Safety Plan
- ▶ CSR development
 - Revisions
 - New CSR
- ▶ CSR deployment
- ▶ Summary and future activities



Project Overview

▶ **Energy Storage Challenge**

- The timely deployment of safe energy storage systems is complicated because it is challenging to document and validate compliance with current codes and standards, those codes and standards need to be updated and new codes and standards need to be developed

▶ **Project Objective**

- Help with codes and standards updating and provide relevant materials to aid in documenting and verifying compliance with those documents

▶ **Accomplishments**

- Initiated a collaborative work effort with stakeholders on the development of a guide focused on documenting and verifying compliance with current codes and standards
- Identified the need for three new standards, developed a purpose and scope for each and initiated collaborative work to draft criteria
- Identified a number of existing codes and standards needing revision and initiated efforts to help update those documents

Purpose and Expected Outcome Today

Purpose

- ▶ Establish a better understanding of the relevance and importance of codes and standards (CS) to timely deployment of safe EES Safety
- ▶ Provide information on the revision of current CS and development of new CS applicable to ESS
- ▶ Provide information on current CS deployment

Expected Outcomes

- ▶ Recognition that CS must be updated and available to guide timely deployment of safe ESS
- ▶ Knowledge of current and future CS development activities
- ▶ How to most effectively participate in those development activities
- ▶ Understanding various means of deploying those CS



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Safety through Codes and Standards

- ▶ Energy storage and batteries are not new
- ▶ Many safety related issues are the same or similar to those associated with other technologies
- ▶ Some safety issues are unique to energy storage, in general, and others to particular energy storage technologies
- ▶ Current CS provide a basis for documenting and validating system safety
 - Prescriptively
 - On the basis of performance
- ▶ Current CS provide a basis for documenting and validating system safety
- ▶ CS need to be updated to more effectively address the wide range of current and future ESS



DOE OE Strategic Plan to Address ESS Safety Related Issues

Lack of standardized validation protocol

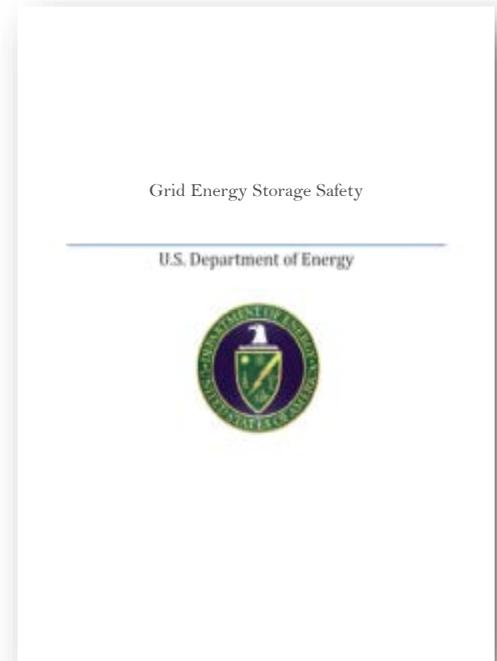
- Science based testing protocols are needed
- Validation protocols must link the materials and cell level to full systems integration into the grid
- Knowledge gained in testing and analysis must be fed back to develop new safer materials

Incident preparedness

- Fire control systems, e.g. fire suppression materials, need to be identified for each storage technology
- First responders education
- Post-incident response

Incomplete and dispersed codes, standards and regulations (CSR)

- The CSRs for energy storage are dispersed throughout many sources (NFPA, IEEE, UL, etc.). Currently there is no central index of all CSR's
- The CSRs need continual updating due to rapid advances in storage technologies and new siting locations



Energy Storage Safety Plan

Scope of Work

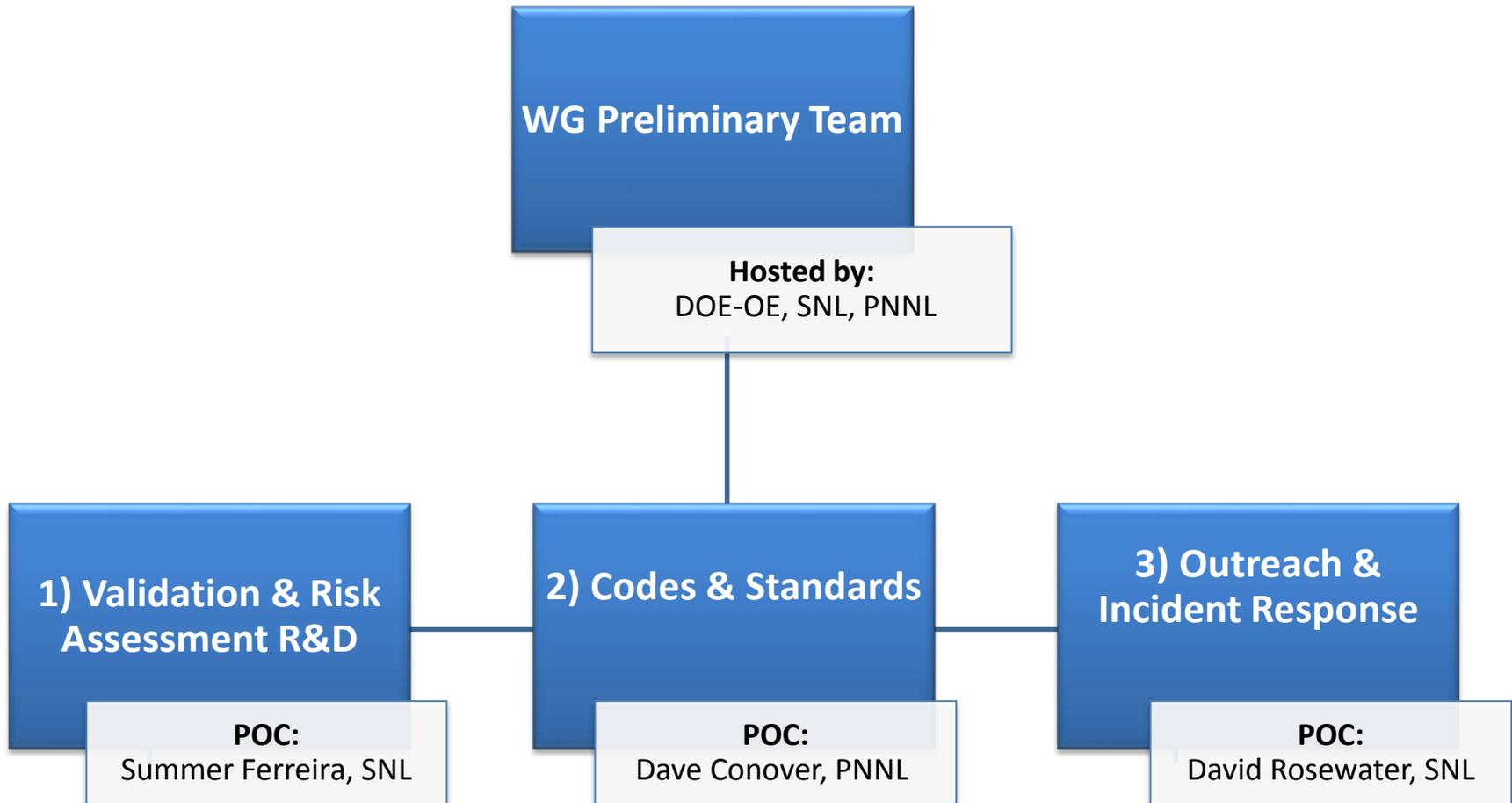
- ▶ Stationary ESS safety
- ▶ Identify activities needed to address known safety-related information gaps
- ▶ Organize project activities under one of three key topical areas
 - *Safety Validation and Risk Assessment*
 - *Codes and Standards*
 - *Safety Outreach and Incident Response*
- ▶ Coordinate all project activities
- ▶ Communicate and foster collaboration
- ▶ Remain dynamic to address technology evolution and new challenges



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Energy Storage Safety Plan Structure



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Energy Storage Safety Plan CS Overview

- 1. CSR IDs needs that require research
- 2. CSR uses output of R&D in CSR efforts

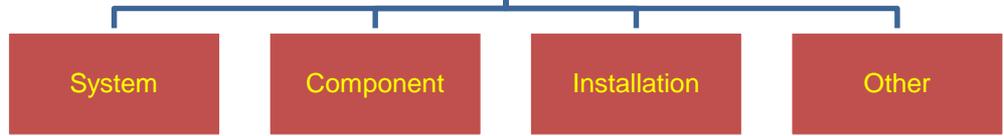
- 1. CSR provides information to support EDU
- 2. CSR uses output of EDU in CSR efforts

1) Validation & Risk Assessment R&D

WG Preliminary Team

2) Codes & Standards

3) Outreach & Incident Response



UL 9540

UL, NEMA, etc.
(addressed by component mfg.)

ICC IFC

NFPA 791

IEC, NEMA, IEEE, CSA, IAPMO, NFPA, ICC, UL, ASME

ID OTHER CSR

NFPA 1 and 70

IEEE 2



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U.S. Codes and Standards

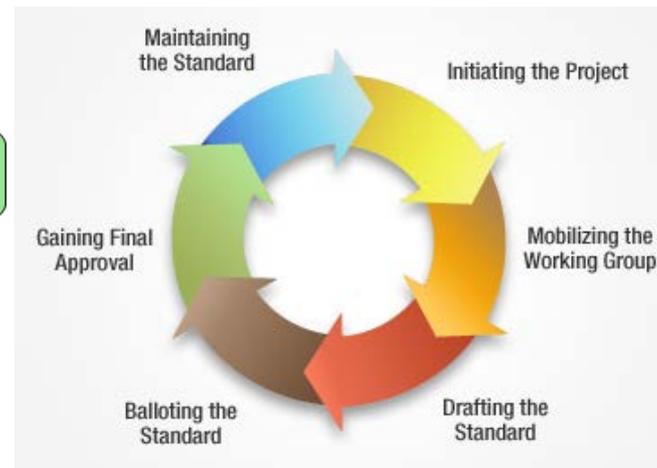
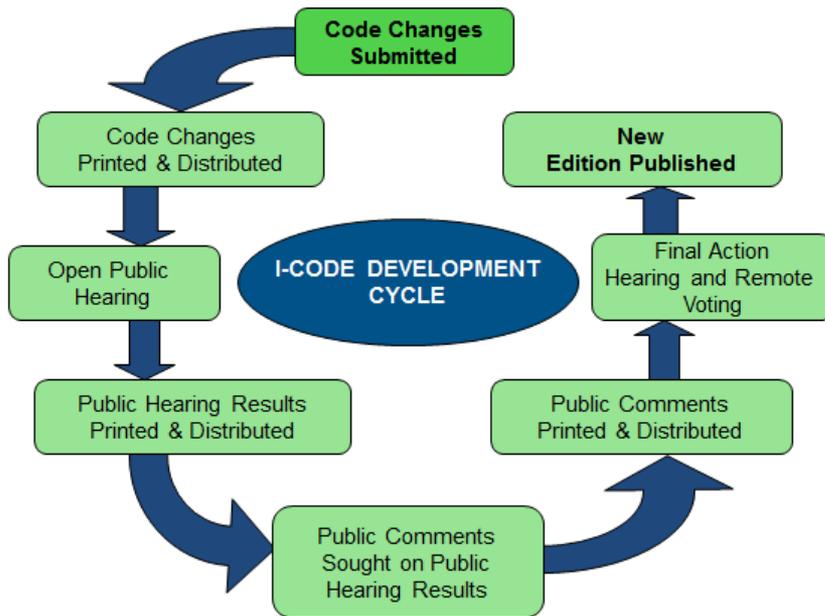
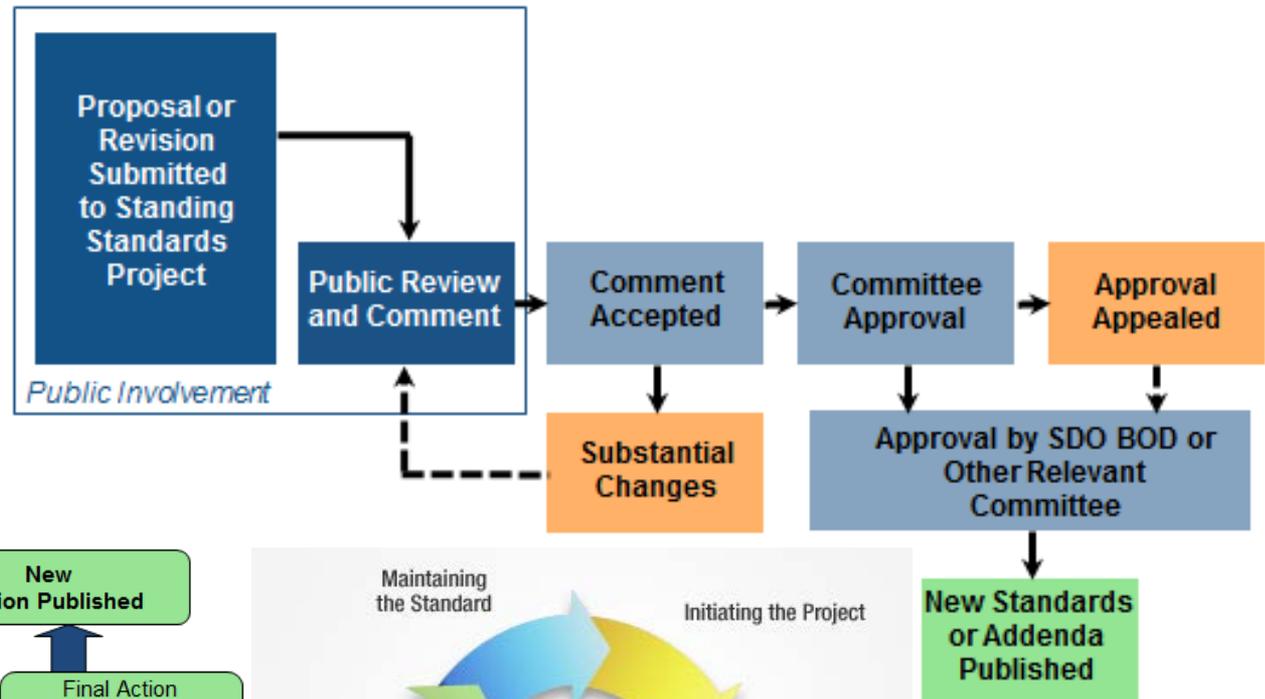
- ▶ Voluntary sector standards and model code **developers**
- ▶ Federal, state, and local government
 - **adoption** of voluntary sector standards and model codes
 - **implementation and enforcement of adopted CS**
- ▶ Utility, insurance underwriter, etc. adoption, implementation, and enforcement of CS
- ▶ The need to document and verify **compliance** with those adopted CS directly and through the efforts of accredited third party agencies



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Examples of CS Development Processes



Standards and Model Code Adoption

- ▶ By Federal, state or local legislative or regulatory action

- ▶ Applicable in all areas covered by the action
 - Mandatory maximum/minimum
 - Mandatory minimum with amendment allowed
 - Mandatory only if agency elects to adopt a code

- ▶ By insurance, builder, utility, etc. action

- ▶ As a criterion for participation in incentives or other programs (e.g. Medicare and Medicaid)

- ▶ As part of a professional practice – ethics



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EES CS WG

Standards and Model Codes

Possible Input Processes

1 **Communicate** What SDOs are Doing

Individuals Submit Their Own Input to SDO

2 Individuals Submit Their Own Input to TG

ESS CSR WG TG Compiles and Facilitates **Coordination** of Input to SDO

3 Individuals Submit Their Own Input to TG

Collaborate Through TG on a Singular Submission to SDO



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UL Standards 'On Radar'

Standard	Title	Upcoming Actions
UL 1973	Batteries for Use in Light Electric Rail (LER) Applications and Stationary Applications	<ul style="list-style-type: none"> • 2nd revision ballot completed affirmative in July 2015 • Revised based upon comment and re-ballot in August 2015 • Bi-national ballot to go out in Q4 2015
UL 9540	Energy Storage Systems and Equipment	<ul style="list-style-type: none"> • Preliminary review completed • Revised document for ballot out in August 2015 • 30-45 Day review period • Completed Q4 2015 • Webinar available for viewing
UL 1741	<i>Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources</i>	<ul style="list-style-type: none"> • <i>Bulletin to update to include advanced grid support utility interactive inverter criteria is out</i> • <i>Revision completed Q4 2015</i>
UL 9741	<i>Bidirectional Electric Vehicle (EV) Charging System Equipment</i>	<ul style="list-style-type: none"> • <i>installation and connection of the EV to buildings as a power source maybe covered in 625.48 of the 2014 NEC</i>
UL 62109-2	<i>Safety of power converters for use in photovoltaic power systems – Part 2: Particular requirements for inverters.</i>	<ul style="list-style-type: none"> • <i>Published</i>

IEEE Standards 'On Radar'

Standard	Title	Upcoming Actions
IEEE P2030.2.1	Guide for Design, Operation, Maintenance of Battery Energy Storage Systems, both Stationary and Mobile, and Applications Integrated with Electric Power Systems	<ul style="list-style-type: none"> Working Group is active in development of a standard
IEEE P2030.3	Standard for Test Procedures for Electric Energy Storage Equipment and Systems for Electric Power Systems Applications	<ul style="list-style-type: none"> Working Group is active in development of a standard
IEEE C2	National Electrical Safety Code	<ul style="list-style-type: none"> NESC SC WGs and SCs to consider all input on change proposals and prepare final report S/O 2015 Proposed revision to NESC Committee for letter ballot and concurrent ANSI PR January 2016 Publication of 2017 Edition August 2016
IEEE 1635-2012R (ASHRAE GPC 21-2012R)	Guide for the Ventilation and Thermal Management of Batteries for Stationary Applications	<ul style="list-style-type: none"> Undergoing revision GPC 21 hopes to have a draft suitable for public review to IEEE in November 2015 Public review and comment is through the IEEE process

IEEE Power and Energy Society Stationary Batteries Committee

<input checked="" type="checkbox"/>	Battery Charger Working Group	PE/SB/Chargers
<input type="checkbox"/>	Codes Working Group	PE/SB/Codes
<input type="checkbox"/>	Main Committee (for meeting attendance only)	PE/SB/MCATT
<input type="checkbox"/>	Nuclear Battery Working Group	PE/SB/Nuclear
<input type="checkbox"/>	SDS Task Force WG	PE/SB/SDSTF
<input checked="" type="checkbox"/>	Ni-Cd Installation, Maintenance and Testing Working Group	PE/SB/WG_1106
<input checked="" type="checkbox"/>	Ni-Cd Battery Sizing Working Group	PE/SB/WG_1115
<input checked="" type="checkbox"/>	UPS Battery Working Group	PE/SB/WG_1184
<input checked="" type="checkbox"/>	VRLA Battery Installation Working Group	PE/SB/WG_1187
<input checked="" type="checkbox"/>	VRLA Maintenance and Testing Working Group	PE/SB/WG_1188
<input checked="" type="checkbox"/>	VRLA Selection Working Group	PE/SB/WG_1189
<input checked="" type="checkbox"/>	Battery Protection Working Group	PE/SB/WG_1375
<input checked="" type="checkbox"/>	Battery Monitoring Working Group	PE/SB/WG_1491
<input type="checkbox"/>	Spill Containment Working Group	PE/SB/WG_1578
<input type="checkbox"/>	Recommended Practice for Stationary Battery Electrolyte Spill Containment and Management	PE/SB/WG_1578/P1578

IEEE Power and Energy Society Stationary Batteries Committee

<input checked="" type="checkbox"/>	<input type="checkbox"/>	Portable Computer Battery Working Group	PE/SB/WG_1625
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Ventilation Working Group	PE/SB/WG_1635
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Battery Technician Qualification Working Group	PE/SB/WG_1657
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Application and Management Battery Cycling Working Group	PE/SB/WG_1660
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Emerging Battery Technology Working Group	PE/SB/WG_1679
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Lithium battery WG	PE/SB/WG_1679.1
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Sodium Battery WG	PE/SB/WG_1679.2
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Cell Phone Battery Working Group	PE/SB/WG_1725
	<input type="checkbox"/>	Rechargeable Batteries for Digital Cameras and Camcorders	PE/SB/WG_1825
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Glossary Working Group	PE/SB/WG_1881
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Working Group for Vented Lead Acid Maint and Testing	PE/SB/WG_450
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Vented Lead-Acid Batteries Working Group	PE/SB/WG_484
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Vented Lead Acid Sizing Working Group	PE/SB/WG_485
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Nuclear Battery Qualification Working Group	PE/SB/WG_535
<input checked="" type="checkbox"/>	<input type="checkbox"/>	DC System Design Working Group	PE/SB/WG_946



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NFPA Standards 'On Radar'

Standard	Title	Upcoming Actions
NFPA 1	Fire Code	<ul style="list-style-type: none"> • Thirteen proposals related to ESS submitted by July 2015 deadline • One change is to increase scope of Chapter 52 from batteries to ESS • Working group on energy storage (that is also working on IFC changes) will likely take the lead in refining that Chapter 52 change during the NFPA process • First draft report March 2016 • Public comment closing May 2016 • Second draft report January 2017
NFPA 101	Life Safety Code	<ul style="list-style-type: none"> • Public input closing date July 2015 • First draft report March 2016 • Public comment closing May 2016 • Second draft report January 2017
NFPA 5000	Building Construction and Safety Code	
NFPA 70	National Electrical Code	<ul style="list-style-type: none"> • New Article 706 on ESS submitted November 2014 • Public comment closes September 25, 2015 • Second draft report April 2016 • Motions Committee Report May 2016

NFPA Standards 'On Radar'

Standard	Title	Upcoming Actions
NFPA 70E	Standard for Electrical Safety in the Workplace	<ul style="list-style-type: none"> Public input closing date July 2015 First draft report posting March 2016
NFPA 11	Standard for Low-, Medium-, and High-Expansion Foam	<ul style="list-style-type: none"> Public input closing date July 2016
NFPA 12	Standard on Carbon Dioxide Extinguishing Systems	<ul style="list-style-type: none"> Public input closing date January 2016
NFPA 13	Standard for the Installation of Sprinkler Systems	<ul style="list-style-type: none"> Public input closing date July 2016
NFPA 15	Standard for Water Spray Fixed Systems for Fire Protection	<ul style="list-style-type: none"> Public input on second draft closing date May 2015 Second draft report January 2016 Motions Committee report posting April 2016
NFPA 16	Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems	<ul style="list-style-type: none"> Public input closing date January 2017

NFPA Standards 'On Radar'

Standard	Title	Upcoming Actions
NFPA 750	Standard on Water Mist Fire Protection Systems	<ul style="list-style-type: none"> Public input closing date July 2016
NFPA 2001	Standard on Clean Agent Fire Extinguishing Systems	<ul style="list-style-type: none"> Public input closing date January 2016
NFPA 791	Recommended Practice and Procedures for Unlabeled Electrical Equipment Evaluation	<ul style="list-style-type: none"> First draft public input closing date July 2015 First draft report posting March 2016 Second draft public comment May 2016
NFPA 72	National Fire Alarm and Signaling Code	<ul style="list-style-type: none"> Public input closing date July 2016
NFPA 91	Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids	<ul style="list-style-type: none"> Public input closing date January 2018
NFPA 92	Standard for Smoke Control Systems	<ul style="list-style-type: none"> Public input closing date January 2016

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NFPA Standards 'On Radar'

Standard	Title	Upcoming Actions
NFPA 110	<i>Standard for Emergency and Standby Power Systems</i>	<ul style="list-style-type: none"> • <i>Public input closing date July 2016</i>
NFPA 111	<i>Standard on Stored Electrical Energy Emergency and Standby Power Systems</i>	<ul style="list-style-type: none"> • <i>Public input closing date July 2016</i>
NFPA 704	<i>Standard System for the Identification of the Hazards of Materials for Emergency Response</i>	<ul style="list-style-type: none"> • <i>Second draft report posting January 2016</i> • <i>Motions Committee report posting March 2016</i>
NFPA 472	<i>Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents</i>	<ul style="list-style-type: none"> • <i>Public input closing date January 2018</i>
NFPA 1620	<i>Standard for Pre-Incident Planning</i>	<ul style="list-style-type: none"> • <i>2015 Edition completed</i> • <i>Next revision cycle starts Fall 2019</i>

NFPA Standards 'On Radar'

Standard	Title	Upcoming Actions
NFPA 730	<i>Guide for Premises Security</i>	<ul style="list-style-type: none"> • <i>Second draft public comment closing date November 2015</i> • <i>Second draft report posting July 2016</i>
NFPA 731	<i>Standard for the Installation of Electronic Premises Security Systems</i>	<ul style="list-style-type: none"> • <i>Second draft public comment closing date November 2015</i> • <i>Second draft report posting July 2016</i>
NFPA 850	<i>Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations</i>	<ul style="list-style-type: none"> • <i>Public input closing date January 2018</i>
NFPA 853	<i>Standard for the Installation of Stationary Fuel Cell Power Systems</i>	<ul style="list-style-type: none"> • <i>Public input closing date January 2018</i>
NFPA 2	<i>Hydrogen Safety Code</i>	<ul style="list-style-type: none"> • <i>New 2016 edition finalized May 2015</i>
NFPA 55	<i>Compressed Gases and Cryogenic Fluids</i>	<ul style="list-style-type: none"> • <i>Public input closing date June 2016</i>

ASME Standards 'On Radar'

Standard	Title	Upcoming Actions
ASME TES-1	<i>Safety Guideline for Molten Salt Thermal Energy Storage Systems</i>	<ul style="list-style-type: none">• <i>ANSI PINS submitted</i>• <i>Initial meetings held</i>• <i>First draft under development</i>



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NECA Standards 'On Radar'

Standard	Title	Upcoming Actions
NECA 416	<i>Recommended Practice for Installing Stored Energy Systems</i>	<ul style="list-style-type: none"><i>Draft under development</i>



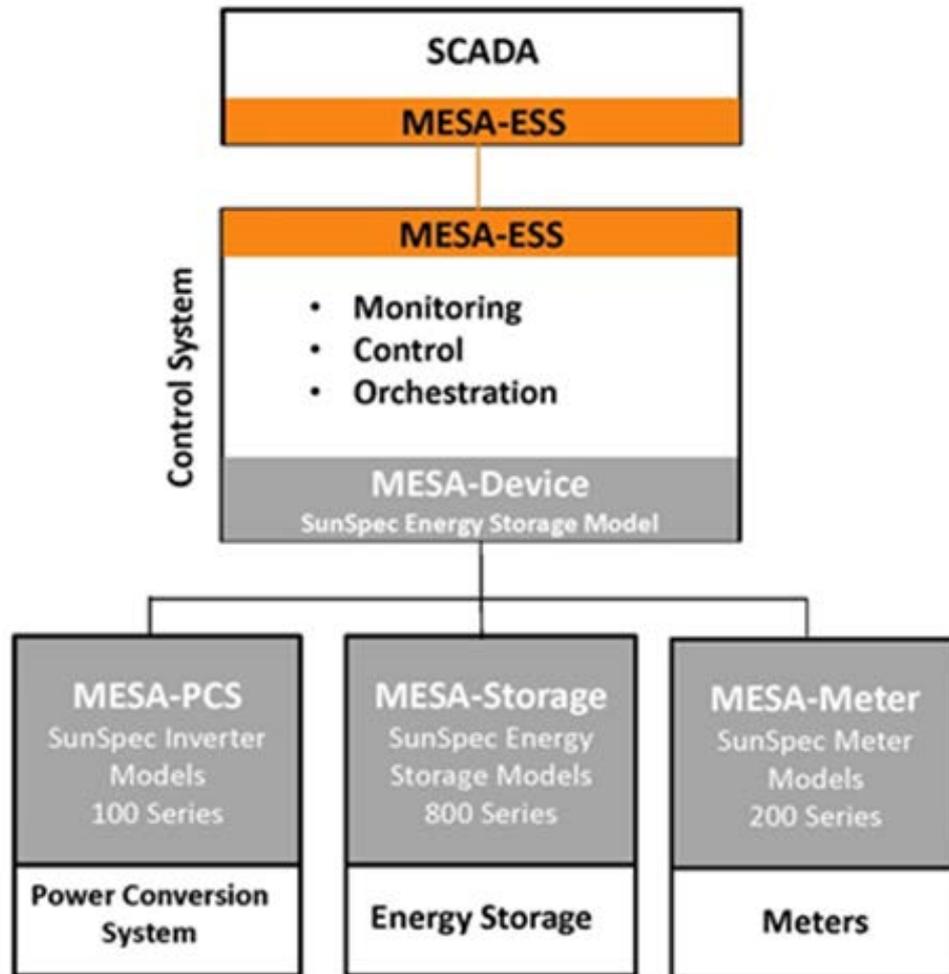
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ICC Model Codes 'On Radar'

Standard	Title	Upcoming Actions
ICC IFC	International Fire Code	<ul style="list-style-type: none"> • A working group on energy storage drafting revisions to Section 608 • Increase scope from batteries to energy storage • Code change draft to be submitted to FCAC November 2015 • Final change to be submitted to ICC January 2016 by FCAC • Change to be processed through the ICC 2016 code development process
ICC IRC	International Residential Code	<ul style="list-style-type: none"> • Proposed changes to the IRC Building provisions due January 2016
ICC IBC	International Building Code	<ul style="list-style-type: none"> • Code development process completed until 2018
ICC IMC	International Mechanical Code	<ul style="list-style-type: none"> • Code development process completed until 2018
ICC IPC	International Plumbing Code	<ul style="list-style-type: none"> • Code development process completed until 2018

IFC Task Group formed under CSR WG to provide input on proposed changes being developed for the IFC

Modular Energy Storage Architecture (MESA) Standards 'On Radar'



- **MESA-Device/SunSpec Energy Storage Model** to address how ESS components communicate with each other and other operational components.
- **MESA-ESS** to address communications between an ESS and utility grid control systems (SCADA/DMS) or other external systems.



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IEC ESS Standards

IEC CDV 62619 (li-Ion industrial cell and battery safety) - CDV out for review and done by SC 21A

IEC NP 62485-5 (Stationary li-ion battery system safety) - NWIP out for review and done by TC 21

IEC FDIS 61427-2: Secondary cells and batteries On-grid PV applications) - FDIS balloted

IEC CD 62932-1, (Flow battery terminology) - CD will be out for review in 2015 and done by TC21/JWG7 of TC s21 and 105

IEC CD 62932-2-1 (Flow battery general requirements & method of test) - CD will be out for review in 2015 and done by TC21/JWG7 of TC s21 and 105

IEC CD 62932-2-2 (Flow battery safety) - CD will be out for review in 2015 and done by TC21/JWG7 of TC s21 and 105



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IEC ESS Standards

All are CDs under development and due out Q4 of 2015

- IEC 62933 (EESS Terminology Standard) – 9/15
- IEC 62934 (EESS Performance Standard) – 12/15
- IEC 62935 (EESS Installation Standard) – 10/15
- IEC 62936 (EESS Environment Technical Specification) – 12/15
- IEC 62937 (EESS Safety Technical Specification – 12/15

Note that these activities occur through IEC TC 120 and US input to that process is through a US TAG to TC 120 that or organized under the auspices of NEMA



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Potential New Standards

Gap	Possible Standard
Safety of electrolytes in flow batteries (toxicity, flammability, corrosive properties, etc.) so one can address conditions of installation and use	Designation and Classification of Electrolytes Used on Energy Storage Systems
Safety of mechanical energy storage systems*	Safety Standard for Mechanical Energy Storage Systems
Confusion associated with the myriad of codes and standards addressing one or more aspects of the installation of an ESS*	Single Installation Standard (one referencing and tying together all relevant codes and standards)

* Task Group being formed under CSR WG to develop initial draft in the form of a protocol that can be used by an SDO for formal standards development

Action Items

Updating Current or Developing New CS

- ▶ ID the standard or model code and sponsoring organization
- ▶ Communicate - Maintain current information about the development process (timing, opportunities for input, etc.)
- ▶ Coordinate - Facilitate participation in those processes and maintain information on who involved in the ESS CSR WG has submitted input to those processes
- ▶ Collaborate – Where desired form a TG under the CSR WG to facilitate the development of a singular and coordinated response to a particular process
- ▶ Where the need for a new standard is identified form a TG under the CSR WG to facilitate the development of an initial draft of the standard



Compliance Guide to Codes and Standards for Stationary Energy Storage Systems

Goal – Development of materials to foster a more timely consideration and approval of ESS under current codes, standards and regulations

Intended use – To provide guidance on documenting compliance with current safety-related codes and standards to proponents of energy storage technologies and guidance on verifying compliance with those same codes and standards by those responsible for the approval and/or acceptance of energy storage technologies.

- Scope and purpose
- General overview of CSR development, adoption and enforcement
- Presentation of questions that will be addressed for users of the guide
- Review and approval of energy storage systems and their components
- Review and approval of the manner in which the ESS and components are installed
- ESS review and approval template
- Case studies
- Reference materials



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 - National Electrical Manufacturers Association
 - National Fire Protection Association
 - Sandia National Laboratory
 - Underwriters Laboratory

Q/A and Further Information



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<http://www.sandia.gov/ess/safety.html>



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